Fibers for Big Boss

Optical Performance

- Throughput
  - Fiber
  - End finishing
- Focal ratio degradation

Opto-Mechanical

- Fiber construction
- Fiber input assembly (actuator)
- Fiber output end slit assembly (spectrograph slit)

Fiber Run & Support

- Focal Plane
- Telescope
- Spectrograph

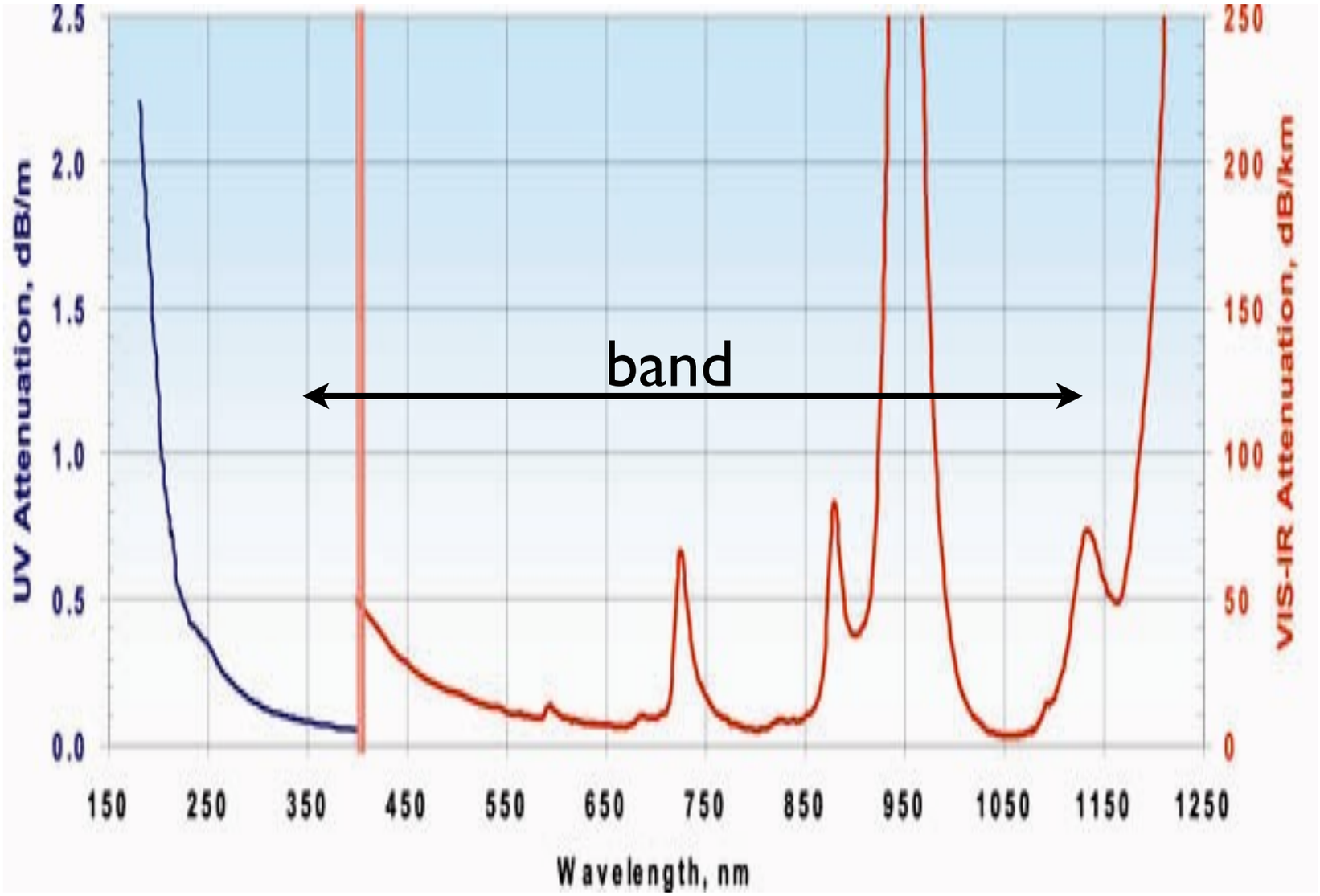
Optical Performance

Bulk Fiber Throughput:

Wavelength dependent attenuation versus length

350 - 1130 nm
high OH silica - good for UV
low OH silica - good for mid-band an NIR

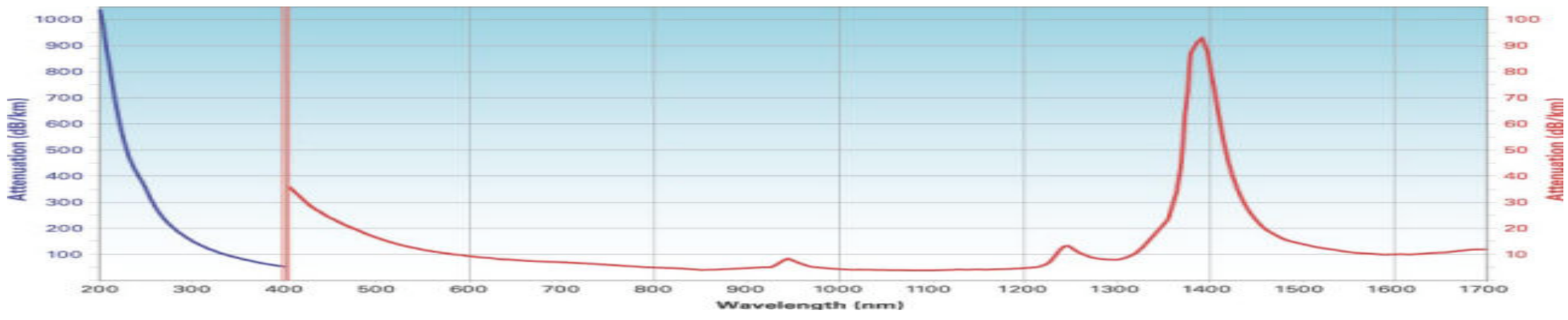
The competitors
Polymicro, NA 0.22
CeramOptec, NA 0.28



Polymicro
attenuation
NA 0.22

High OH FV

Low OH FPB



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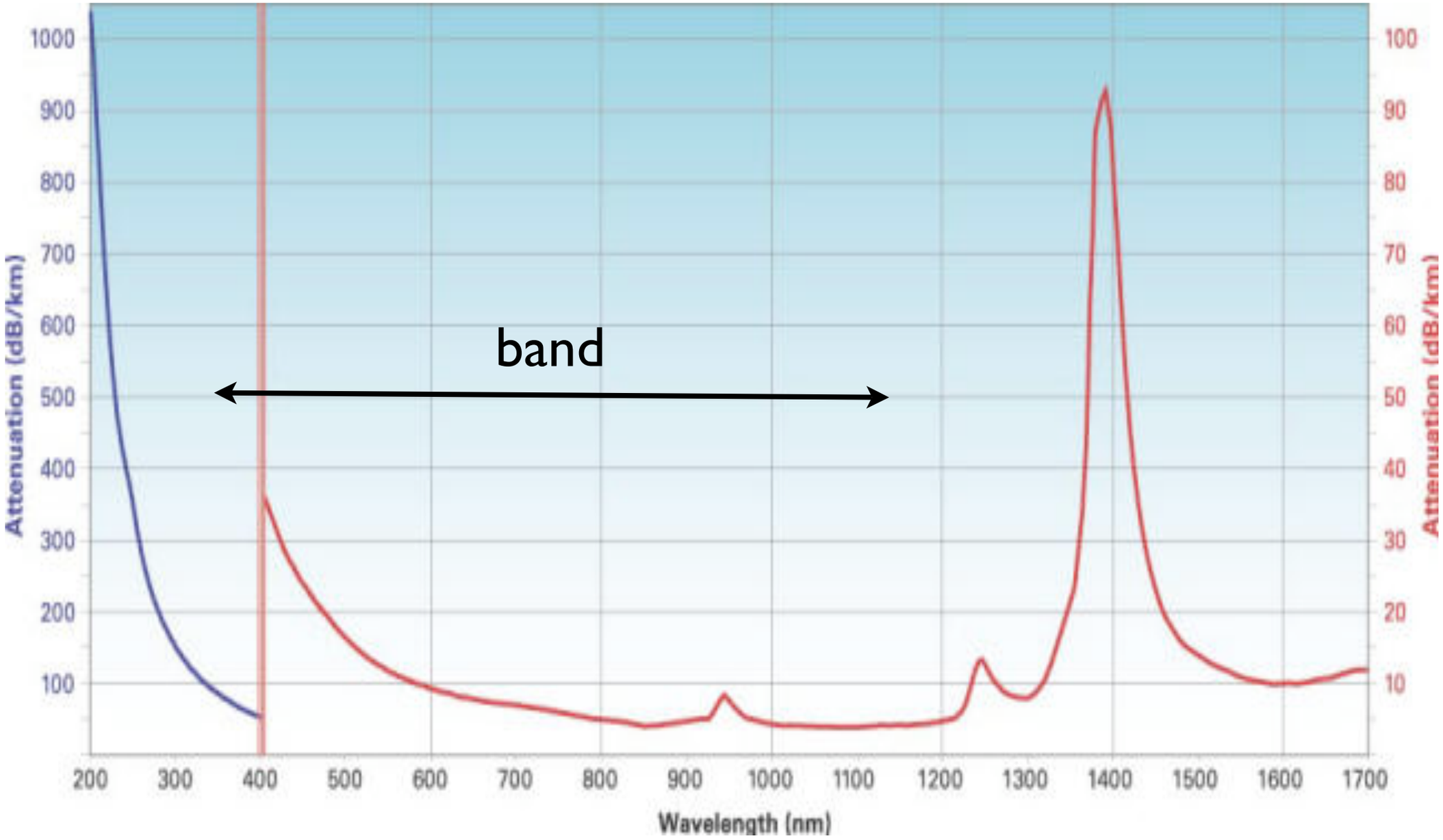
Polymicro Low OH FBP



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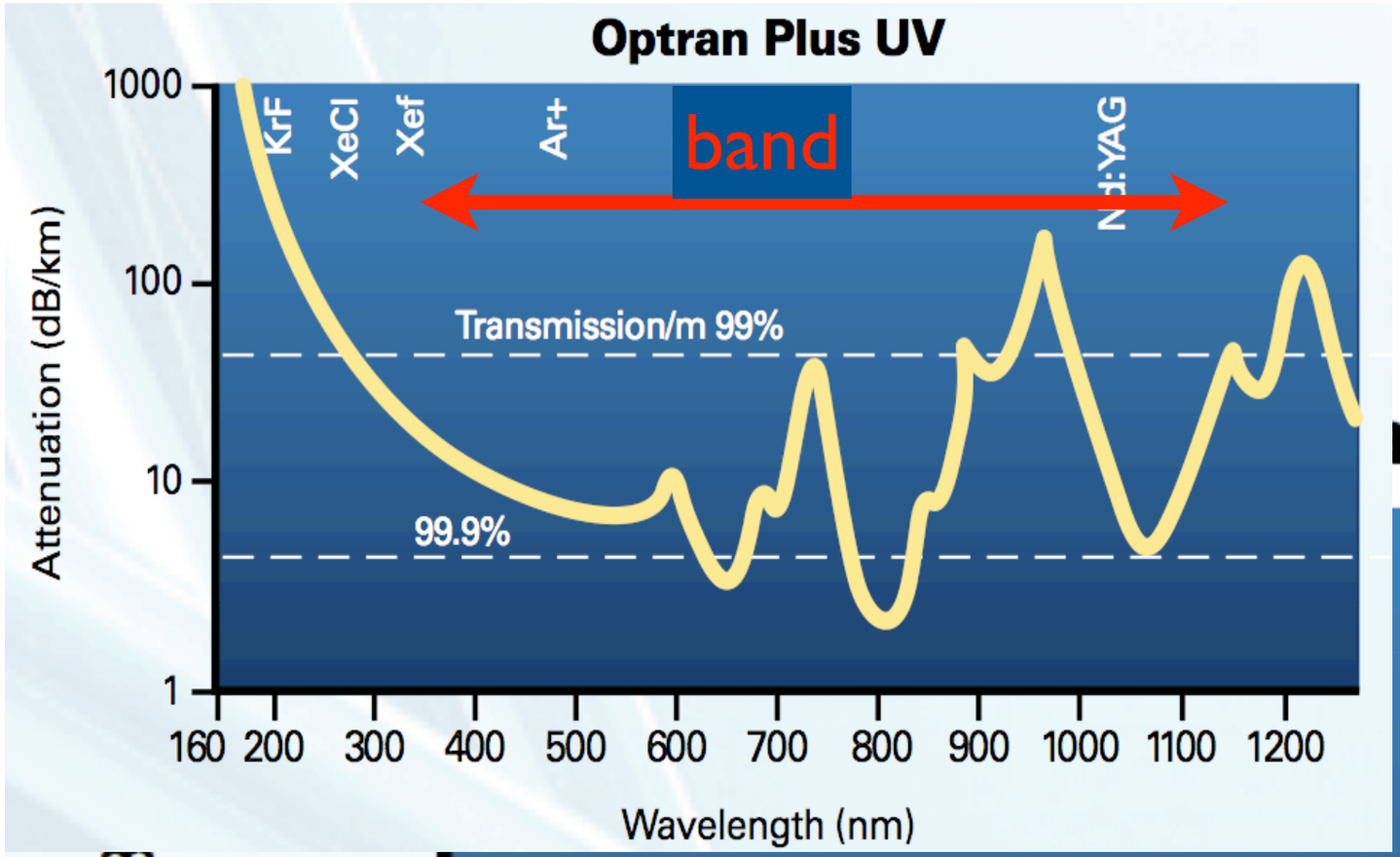
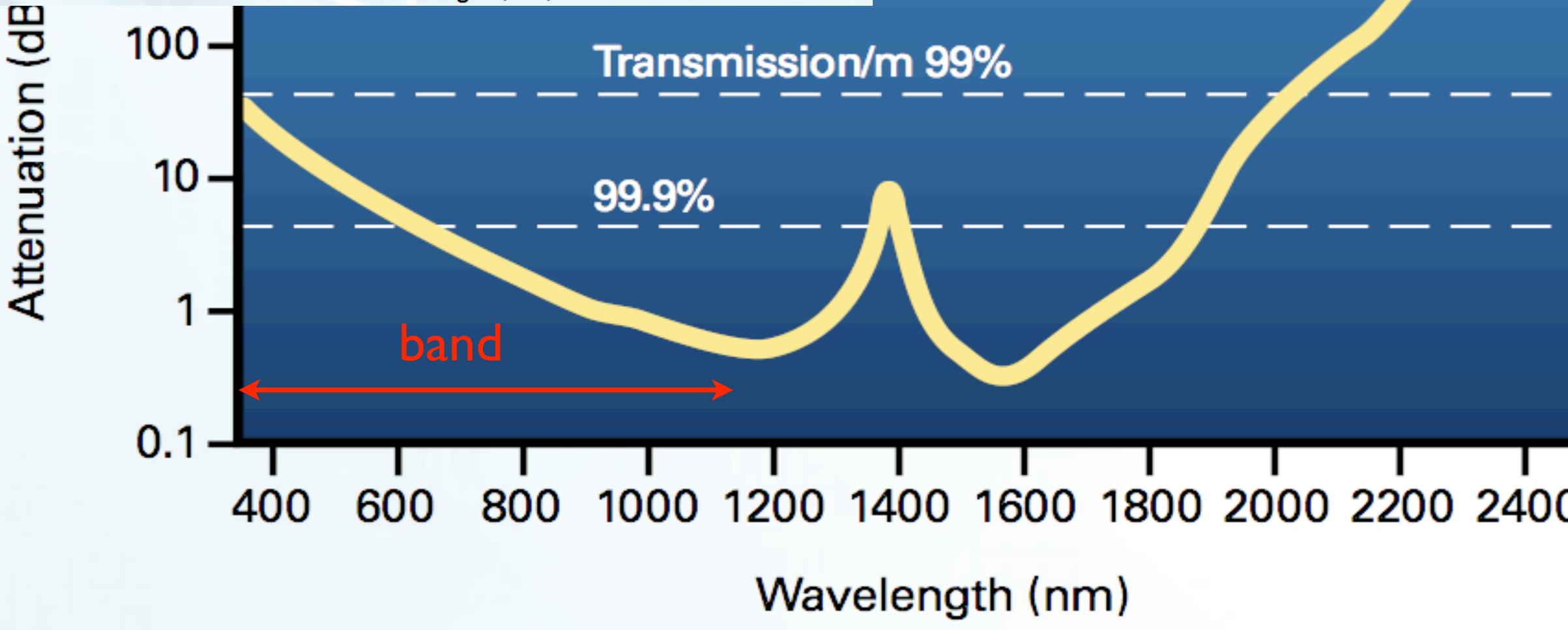
CeramOptec

Optran

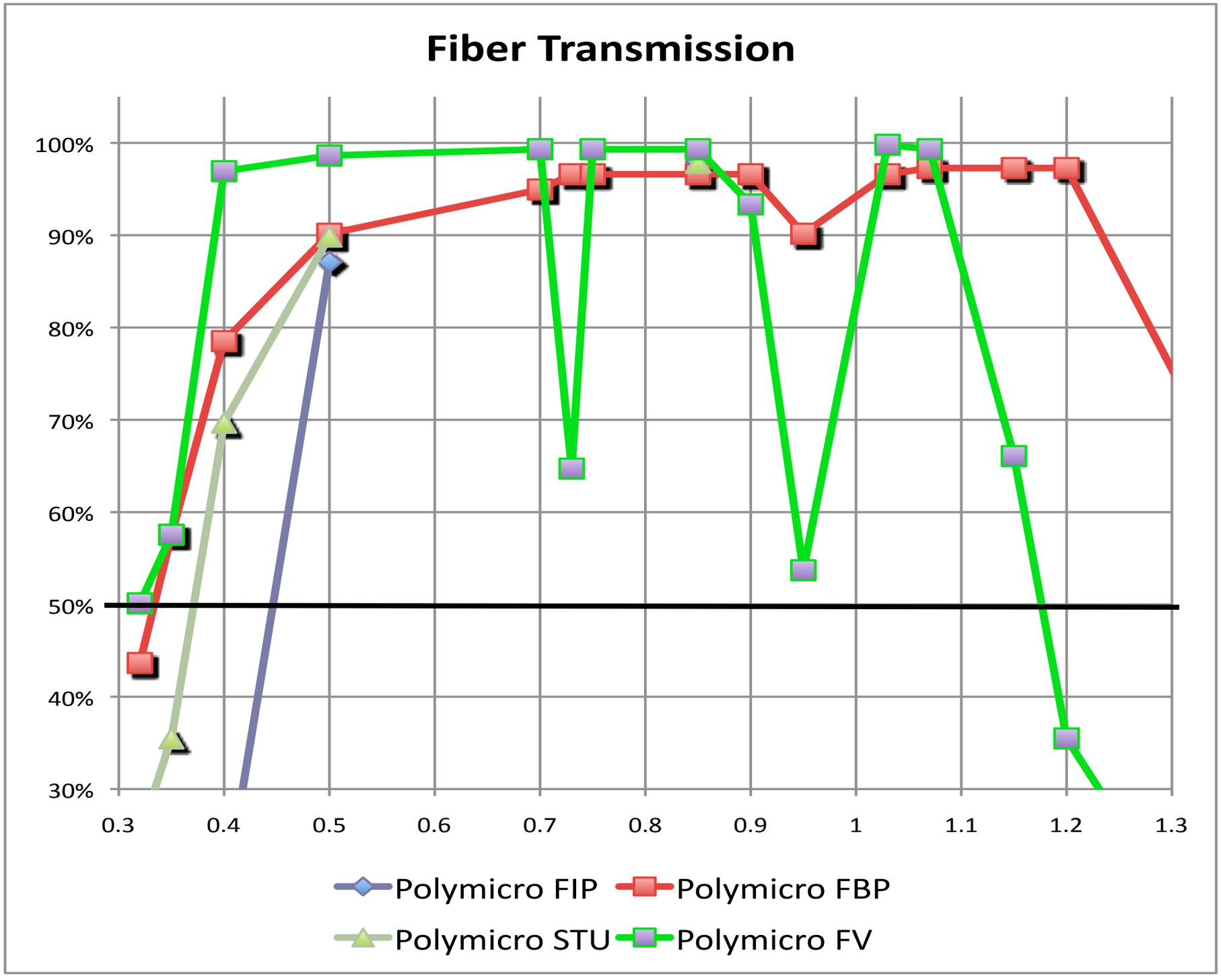
N.A 0.28





Polymicro

30m



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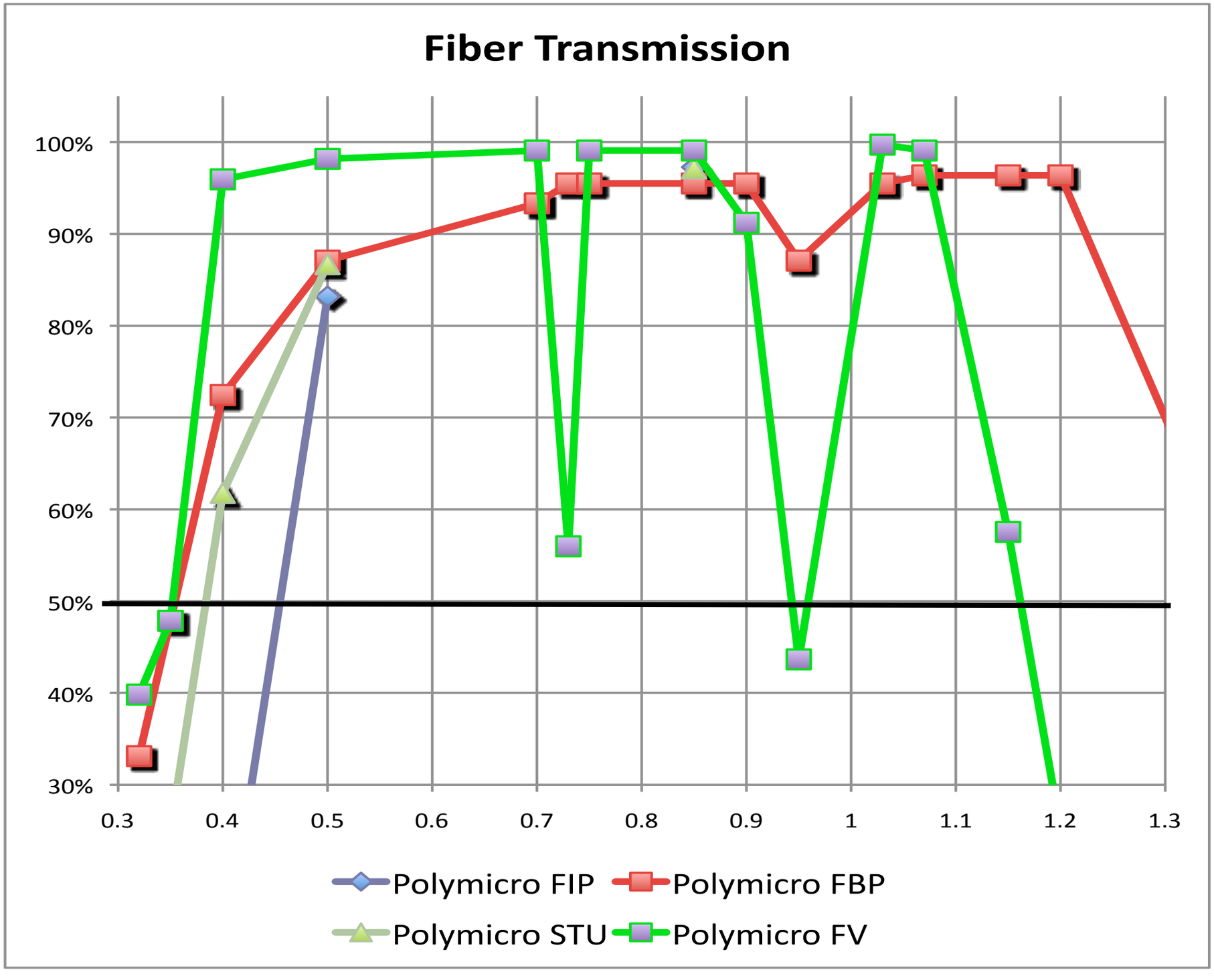
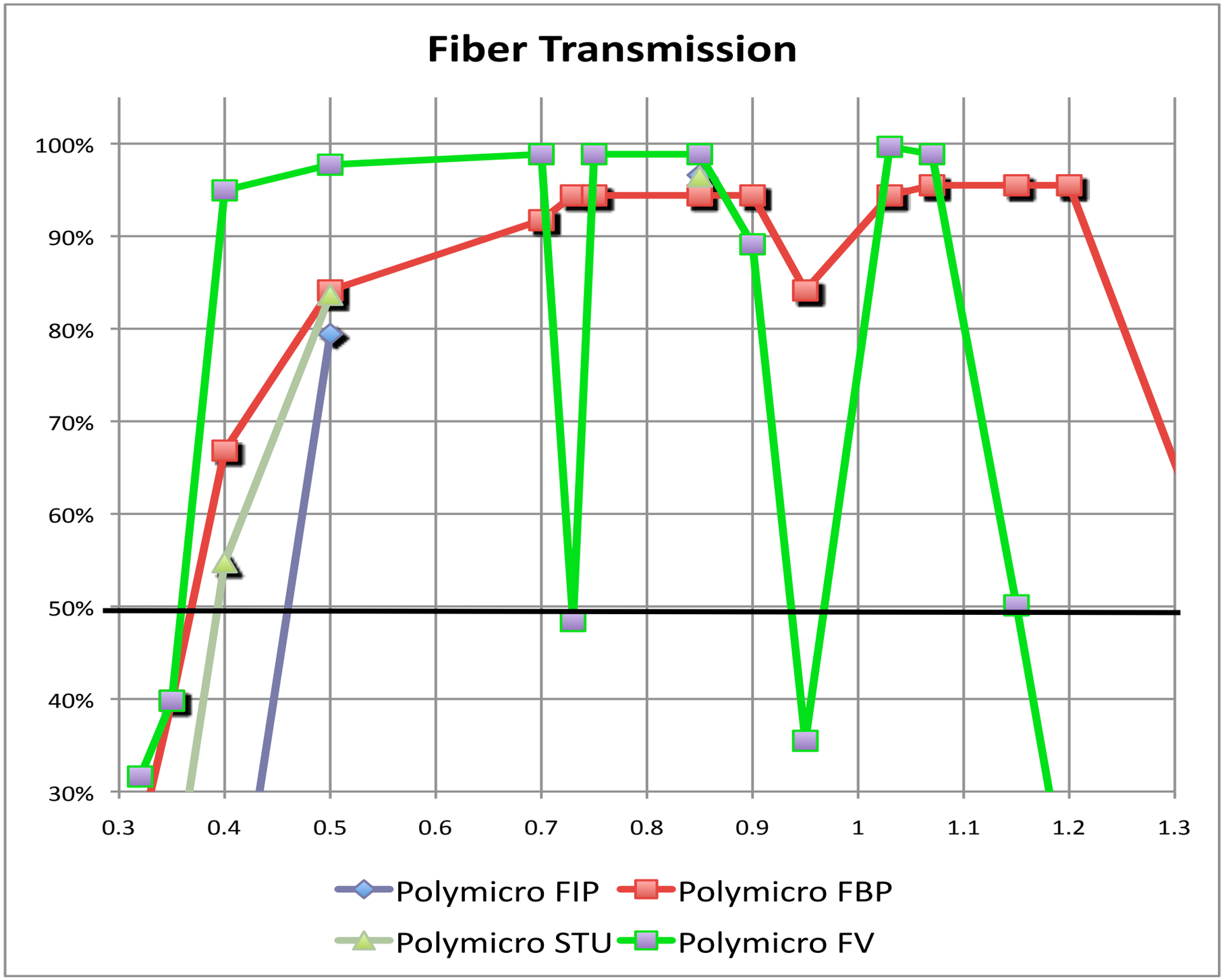
Polymicro

40m



Polymicro

50m



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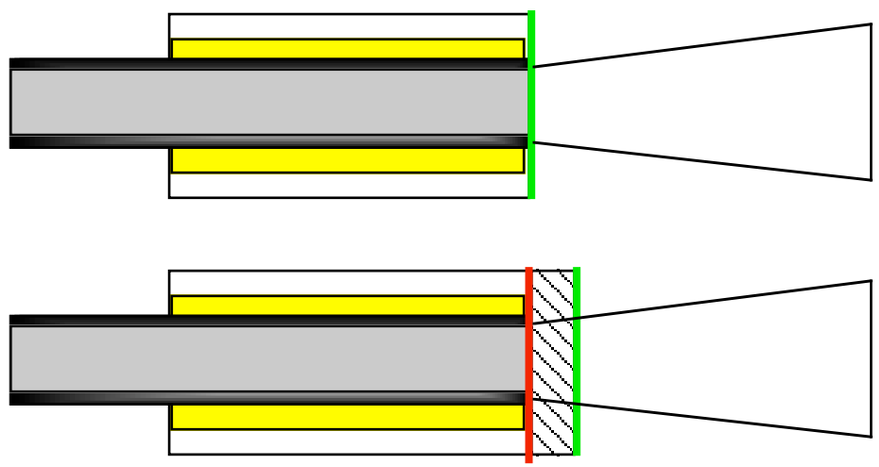
Throughput: End finish AR coating

+ AR ~4% per end

AR direct to fiber ends
(post glue & polish)

AR on cover w/ index matched oil/glue
"fills polishing imperfections"



Throughput: Focal Ratio Degradation (FRD)

f/# Out < f/# In

If spectrograph performs @ f/# out,
then there is no performance loss.

Effects:

-micro-bending in batch glass draw

-stress

. bend radius (< ~250 X fiber dia.)

. jacket contact

. fiber termination mechanical / thermal

@ low f/# - scattering => NA limit losses
@ high f/# - modes are poorly filled, big FRD

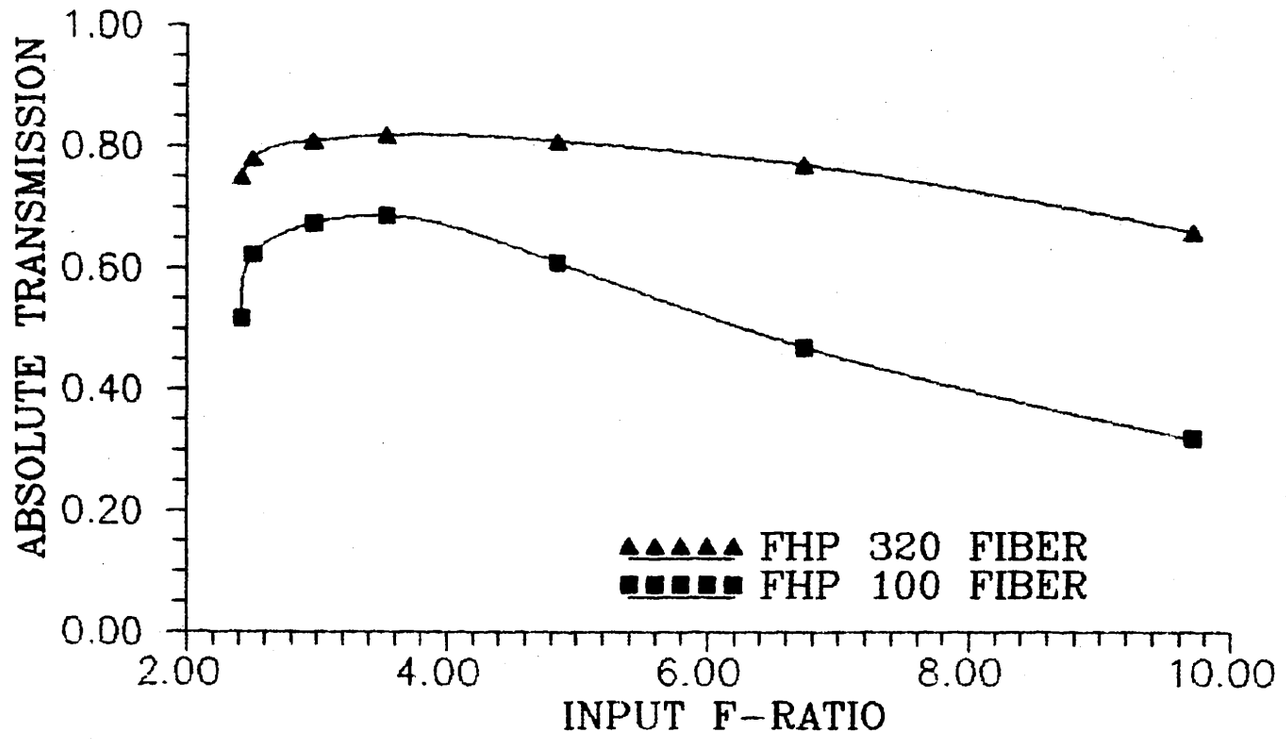


Fig. 7 The vertical axis is the absolute transmission into a aperture equivalent to the input f-ratio given on the horizontal axis. Both the FHP320 and FHP100 fibers are shown.

Focal ratio degradation in optical fibers of astronomical interest
Authors: Ramsey, Lawrence W., 1998 ASPC

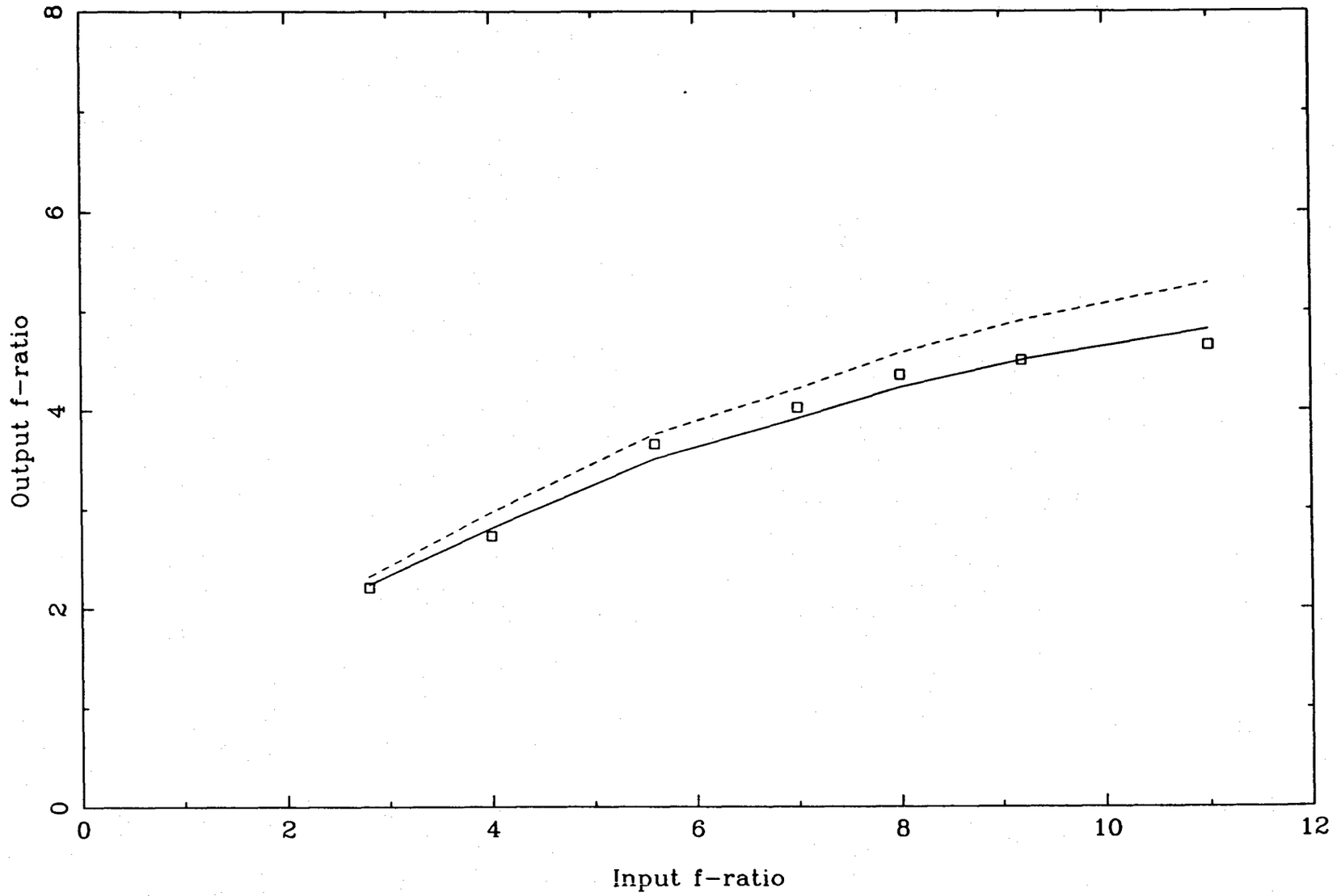


Figure 11. Output *f*-ratio as a function of the input *f*-ratio for the test fibre. The squares are the values obtained from the experimental results and the solid line corresponds to the results obtained from the model's predictions. The values of the output *f*-ratio were derived from output beam profiles shown in Fig. 9. The dashed line corresponds to the predictions from the model without any tilt in the function G.

A method for determining the focal ratio degradation of optical fibres for astronomy
Authors:Carrasco, E.; Parry, I. R.
Mon. Not. R. Astron. Soc., 271, 1

BOSS Fiber FRD tests

Schlegel

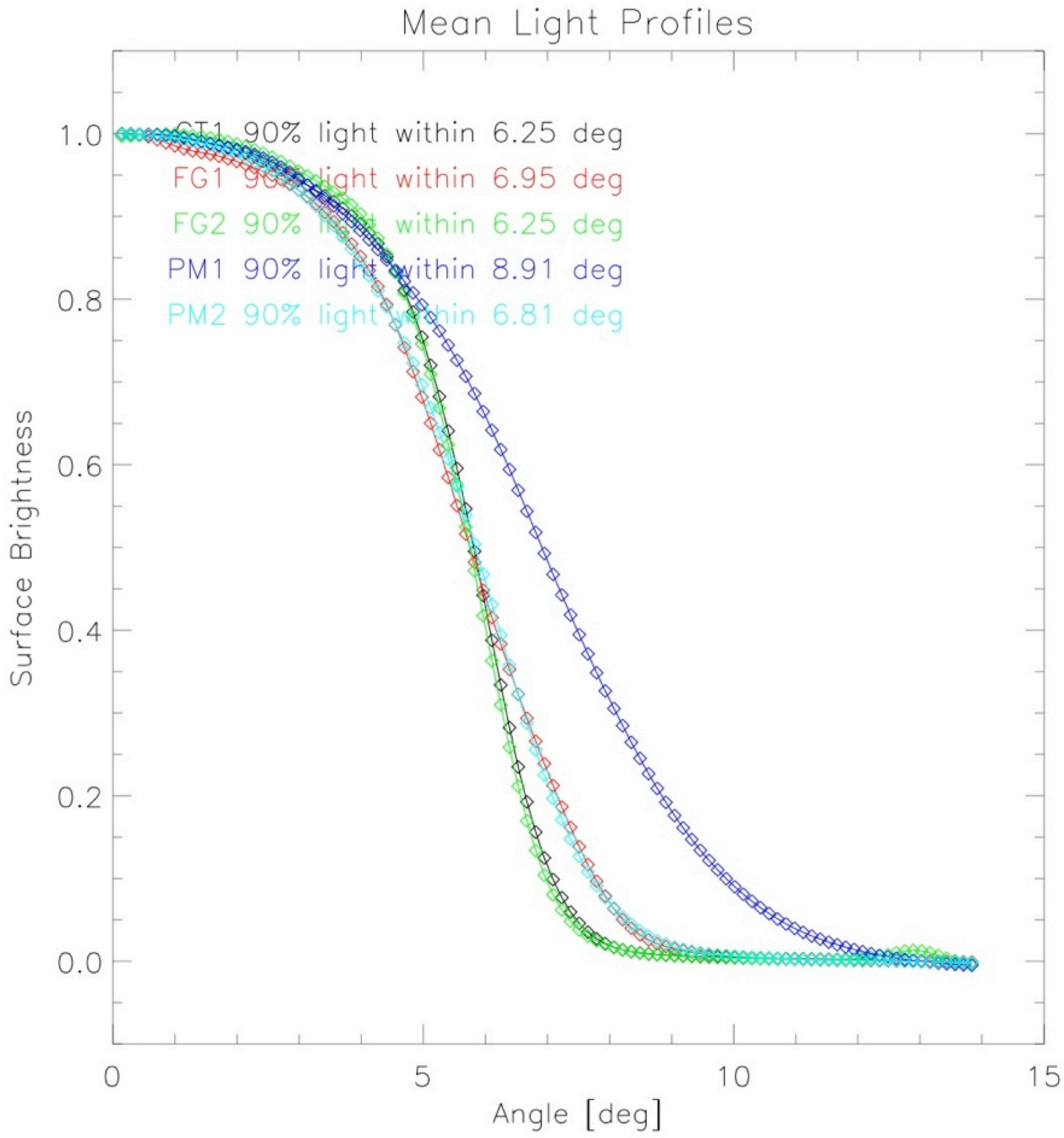
Polymicro FBP fibers
120 micron cores

FRD on fibers delivered by 3 vendors.

We simply illuminated at f/5, and took a picture of the output beam.

Attached are some aggregate profiles.

Results are consistent with just a few percent of the light being thrown at larger angles than captured by our throughput tester.



Opto-Mechanical

Fiber construction

Core & Cladding:

clad ratio 1.1 (to 1.2 for IR)

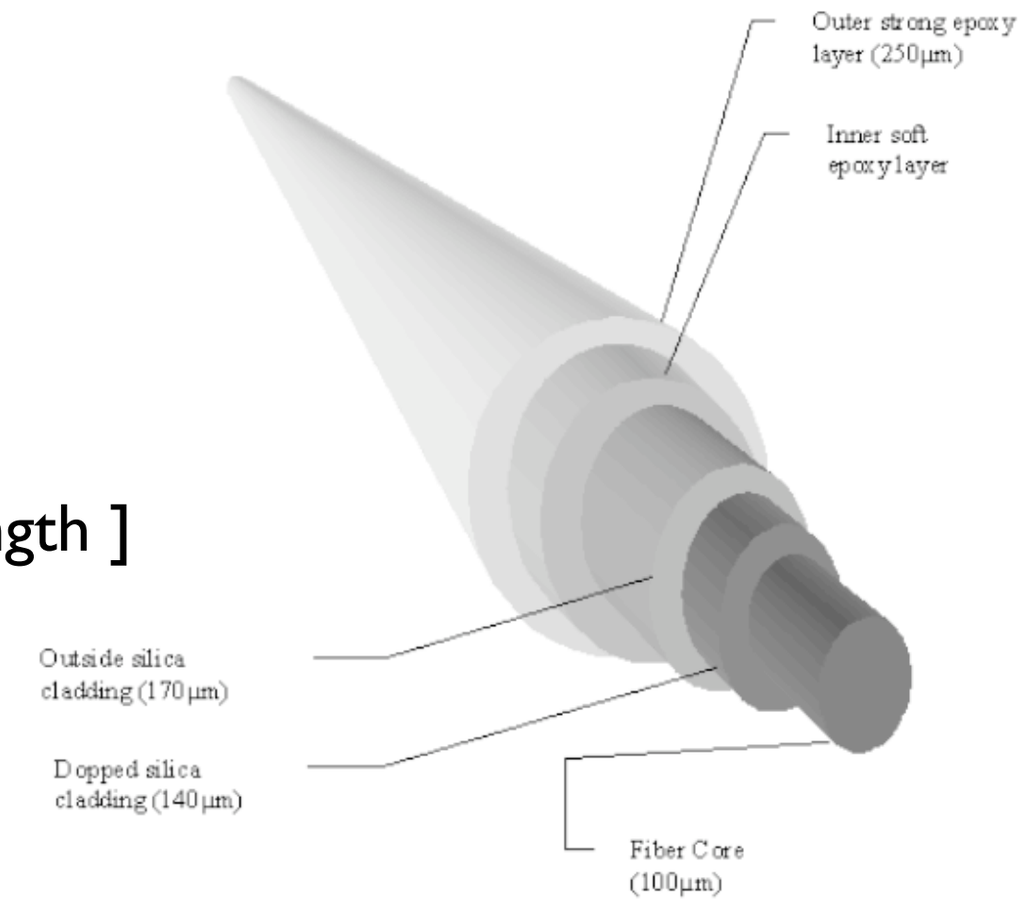
[secondary soft cladding for strength]

Coating

hard (e.g polyimide)

vs.

soft & hard coating (epoxy or acrylic)



Prieto, 2000 VIRMOS

A double layer of cladding
is then applied. The first one is doped silica,
and the second one is pure silica giving robustness to the fiber

External coating an epoxy [or acrylic] double layer coating
The central layer is soft and prevents stress on the fiber,
while the outer one is strong and gives robustness to assembly

Low stress design for fiber survival and FRD stability

- Ferrule material (TCE match) & design
- Glue selection, gap & bonding conditions
- End polishing
- Jacket termination

Positional Tolerances

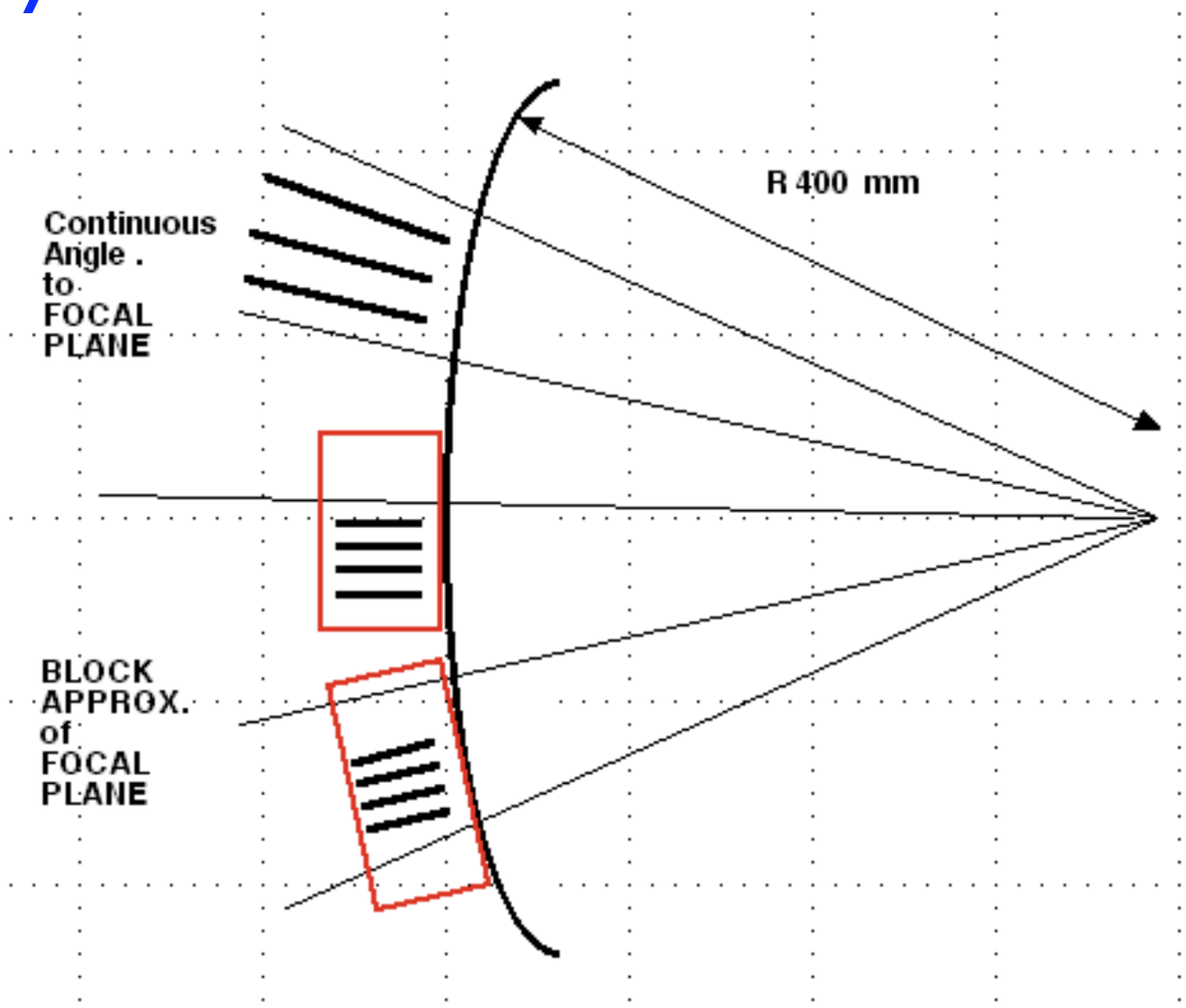
Focal plane:

- Axial position tolerance.
- Angular pointing within FRD

Fiber input & output assembly

<u>Spectrograph feed slit:</u>

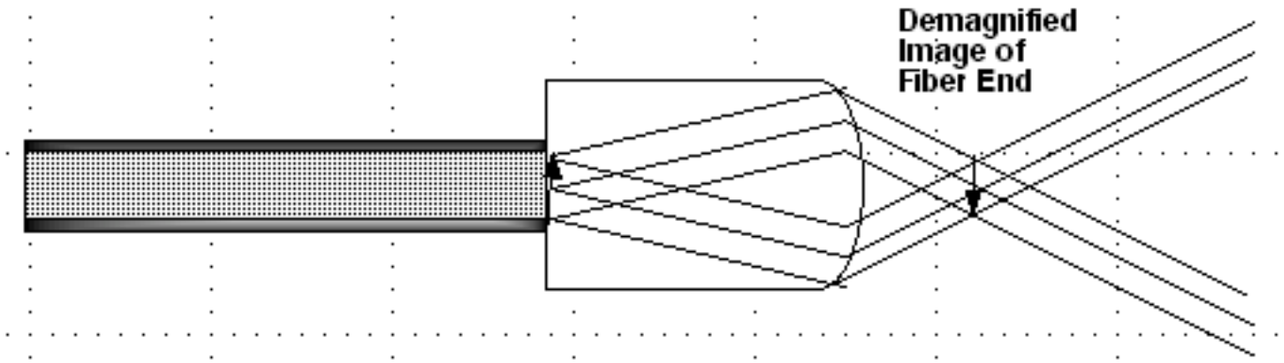
Figure radius tolerance
Lateral tolerance vs dispersion
Angular tolerance vs pupil output
Spacing between fibers



<u>Fiber termination:</u>

V-grooves in Si , +/- 1 um, parallel - Approximate F.P. ?
EDM in metal or ceramic machining, +/- 5 um, aimed grooves
Micro-drilled holes
Stacked fibers, etc.

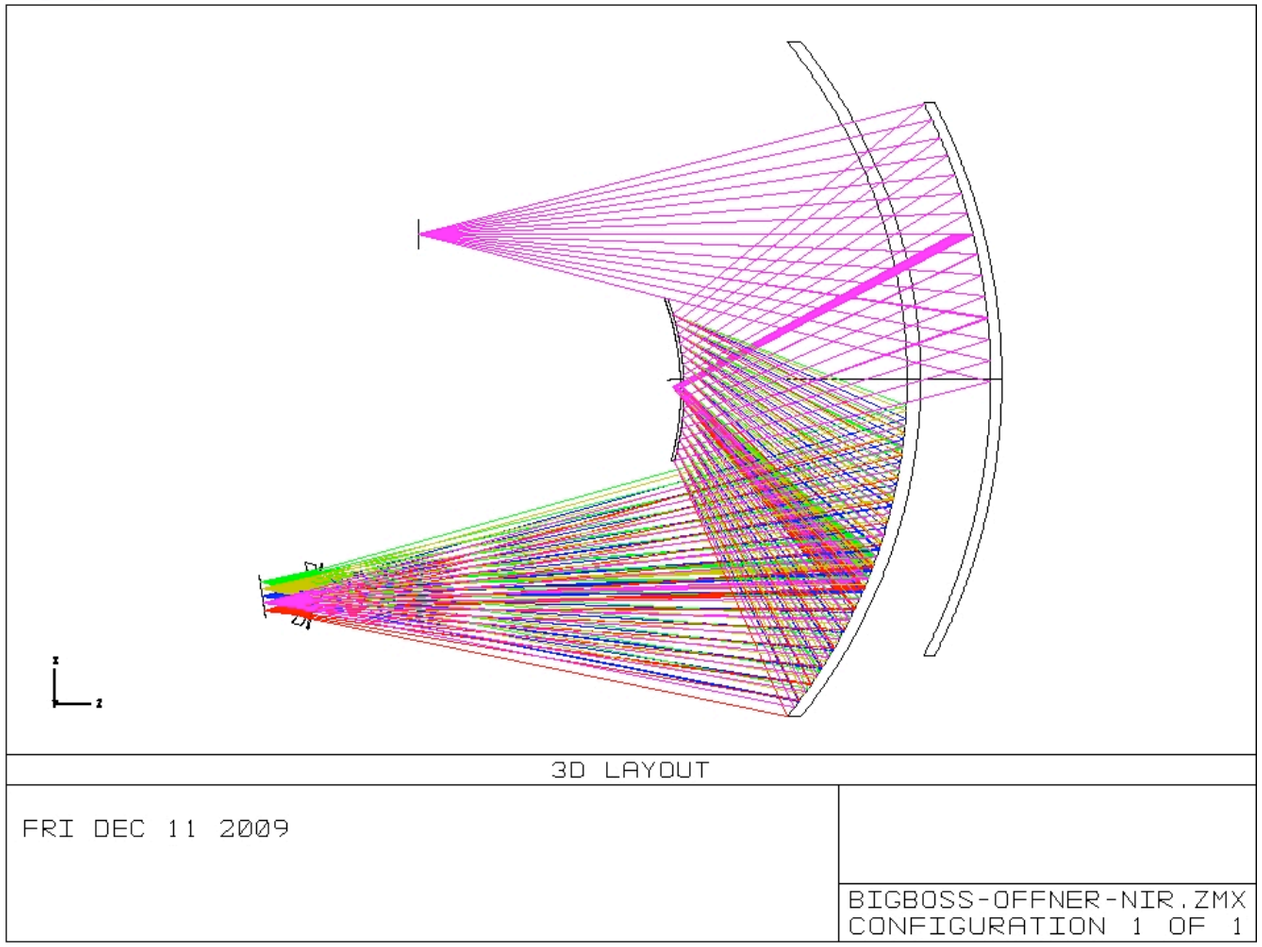
Fiber output assembly - Microlensed ?



- **E. Prieto:**
  - **"The best case for me should be to have 70µm fiber illuminated at F/2.3. Having this, I could use a offner design with the grating on the secondary (see attachement). A solution like this will have high throughput from UV to NIR."**

Micro lens array along slit face (but its curved)

Inter-fiber spacing is limited by lens size



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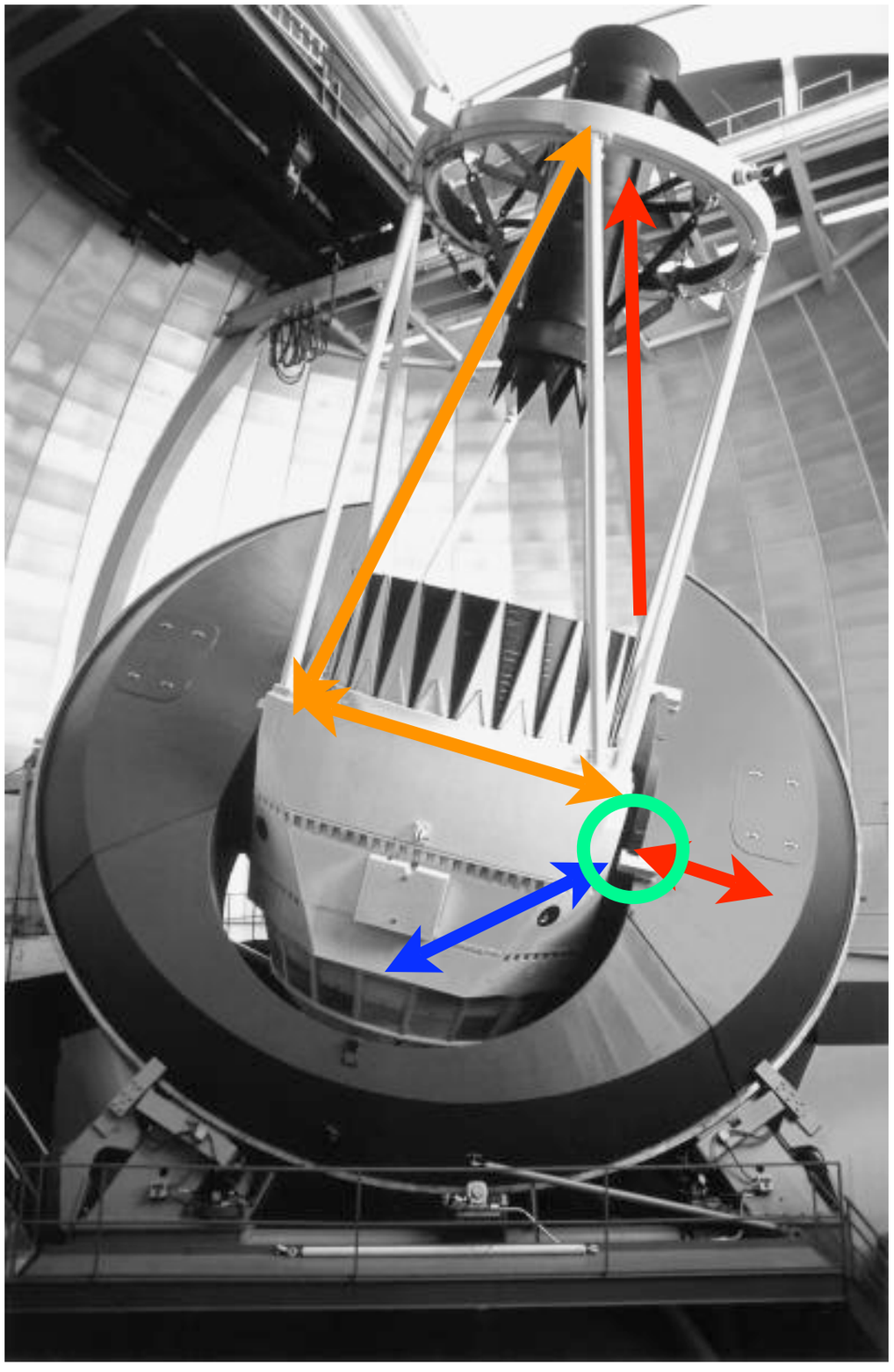
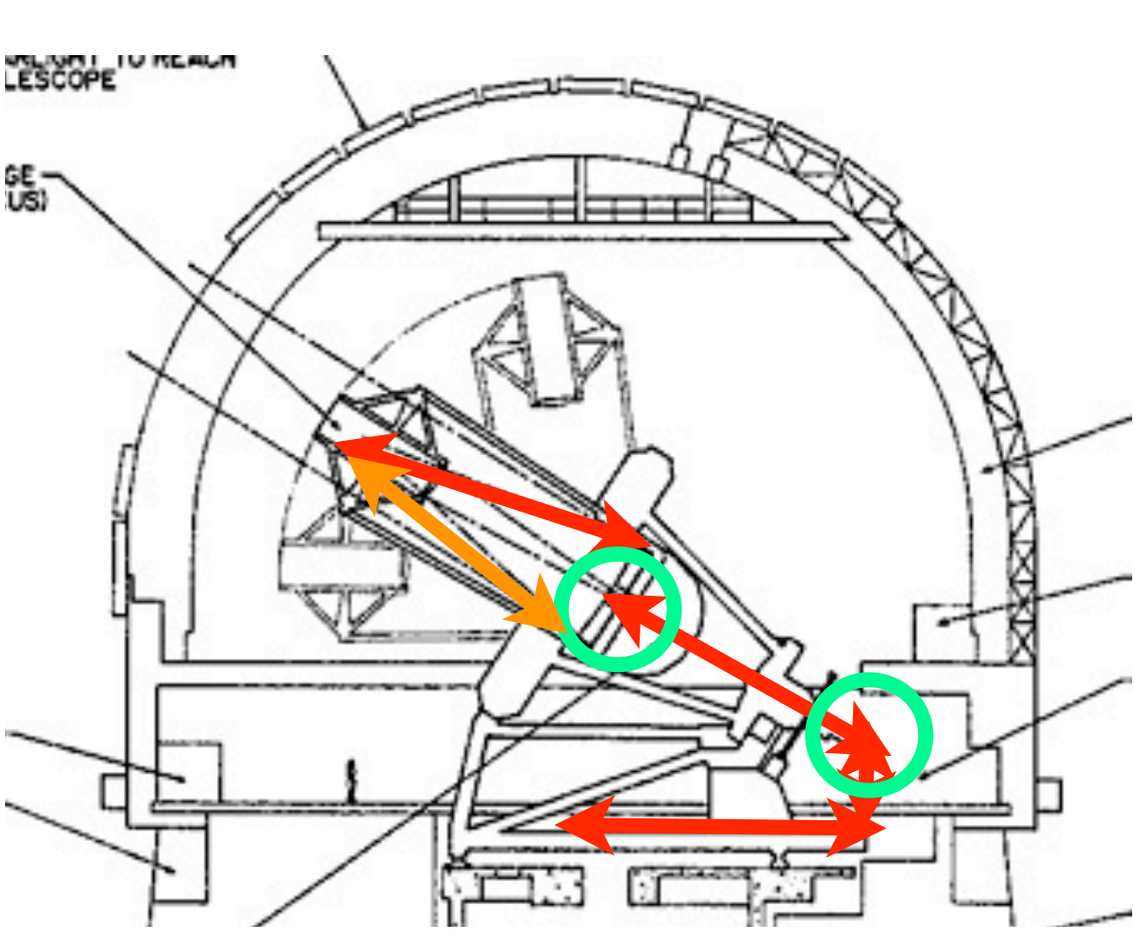
Fiber run & support



30 to 50 (!) meters

Focal plane to El. mount
balanced
Elevation mount rotation scheme
limited clearance !!!
Elevation mount to Polar bearing
Polar mount rotation scheme
Polar mount to spectrograph



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Main Fiber Issues

Fiber type selection

Size & mass of bundle groups (power wires ?)

Fiber routing on telescope

Spectrograph slit tolerance demands

Fiber slit assembly design

Fiber input ferrule design